14.2 NEAR OPERATIONAL SHORT-TERM FORECASTS FROM TWO MESOSCALE MODELS

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1. INTRODUCTION

The NOAA Forecast Systems Laboratory (FSL) has been testing two mesoscale models in real-time for several years, with an initial goal of implementing one of the models for real-time use on a trial basis at the Denver National Weather Service Weather Forecast Office (WFO). The plan is to integrate the model within the FSL-developed WFO-Advanced workstation being tested at the Denver WFO as the prototype for the Advanced Weather Interactive Processing System (AWIPS), for deployment as part of the NWS modernization.

Within the possibilities of the modernization is running local models at a WFO. Along these lines, the FSL Local Analysis and Prediction System (LAPS, McGinley et al., 1991) was developed a number of years ago. The analysis portion of LAPS has been successfully supporting operations at the Denver WFO for several years, and more recently in a number of other NWS offices. The prediction portion of LAPS would come from a mesoscale model such as one of the models being tested at FSL, or possibly one that is tied to a cooperative effort with a nearby university or research laboratory. Details of how this might occur are discussed by Schultz at this conference (Paper 14.3).

Two mesoscale models have been used for testing; one a version of RAMS (CSU Regional Atmospheric Modeling System) and the other of MM5 (Penn State/NCAR Mesoscale Model Version 5). Similarities and differences exist between the models, as further detailed by Snook et al. (1998; also at this conference, Paper 1.2) and Cram and Snook (1996). Both have 10-km horizontal grid resolution covering the area shown in Fig. 1, and 25 layers from the surface to approximately 100 mb (a terrain-following σ_z system for RAMS, σ_p for MM5). Other differences include explicit cloud physics for RAMS compared to a combination of explicit microphysics and a cumulus parameterization scheme for MM5, and different radiation schemes and treatment of the soil layer. Both models were run for 12 h twice a day beginning at 0000 and 1200 UTC and initialized for the area shown in Fig. 1 using LAPS, with boundary conditions from the previous operational Eta model run.

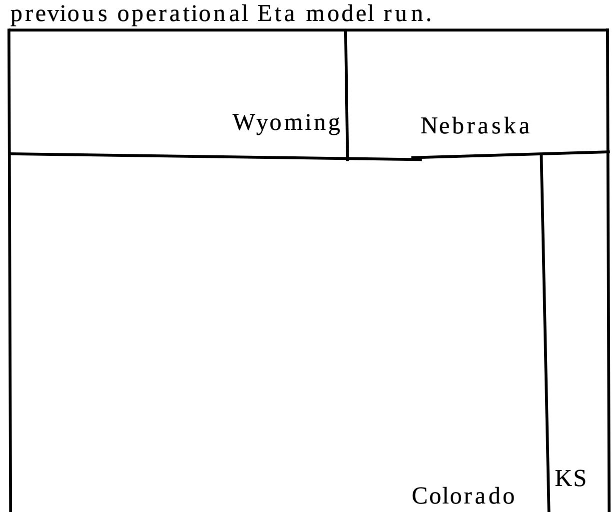

Figure 1. Model domain and county outlines, topography (gray shades, white = highest), and METAR sites .

Both models were run on most days at FSL, with output often available for display on the WFO-Advanced workstation at FSL, though not at the same workstation in Denver. There forecasters could look at selected fields located on the FSL homepage at address http://www.fsl.noaa.gov/wthr/fsl-weather.html. In an attempt to familiarize the forecasters with the performance of the models, a number of cases from this past winter and summer were collected in hardcopy form, categorized, and subjectively compared to observations as well as to performance of other models when possible, and brought down to the WFO.

Quantitative verifications of RAMS and MM5 have been presented previously (Cram and Snook, 1996; Schultz and Snook, 1996), with an updated version elsewhere in this volume (Snook et al.,

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1998). The purpose of this paper is to present a qualitative look at model performance, and to look at a few operational issues regarding how such model output might be used most effectively.

2. OVERVIEW OF MODEL PERFORMANCE

Quite a variety of cases were compiled (Table 1), especially during the 1996-97 winter, which was characterized by a number of smaller scale events. These provided ideal scenarios to test a mesoscale model and see how useful it might be for mesoscale events that were often very difficult to forecast even in the short term (6 to 12 hours).

Table 1. Number and type of events collected

Type of event	Model			
	RAMS	MM5	Mesoeta	Other
Winter events				
Dry Denver Cyclone		1		
Longmont Anticyclone	1	1		
Downslope winds	4	2		
High winds & mtn snow		1		
Orographic (mtn) snows	1	1		
Lee Cyclogenesis	1	1		
Frontal passage-dry	3	2		
Arctic FROPA & snow	2	1		
-upper level low	1	1		
-shortwave & upslope	1			
-CSI & upslope	2	6	1	RUC
Summer events				
Denver Cyclone	4	1	4	
Other surface boundary	1	1	1	ExpRAMS
General thunderstorms	1	1	1	
Nocturnal tstms	1		1	ExpRAMS
Null case (no tstms)	1	1	1	

While the overall number of cases is not sufficient for making any definitive conclusions, there were some trends of model behavior that were observed. One was for the Denver Cyclone (or DCVZ, Szoke et al., 1984), a mesoscale flow feature that develops from southeasterly low-level flow over the topography of the eastern plains of northeastern Colorado (see Fig. 1). Its scale (a circulation of about 50 to 100 km in diameter, or a convergence zone of similar length) makes it a good test for a mesoscale model. Both RAMS and MM5 were able to simulate the zone with relative success, but had some difficulty in developing summertime convection along the zone. The horizontal resolution of the MesoEta was not quite fine enough to simulate the DCVZ. Another topographically forced low-level flow feature of roughly similar scale, the Longmont (LGM) Anticyclone (Wesley et al., 1995), was also simulated by the finer resolution models and to some extent by the MesoEta (Black, 1994).

Both the models, as well as the MesoEta, were able to simulate the positioning of a larger-scale dryline type boundary that develops near the eastern Colorado border, but again thunderstorm development (location, timing, etc.) along the boundary was not as well forecast and also varied among the models. In general, from tracking model performance over a fairly long period when forcing was weak and diurnal upslope trends were the principal mechanism to force thunderstorm development along the Front Range, the RAMS and MM5 models did a credible job with the timing, and to a lesser extent, the location of the first storms of the day. The resolution is not sufficient, however, to model the interactions that might take place after a number of storms develop (isolated supercells might be an exception to this).

For the type of winter events that produced snowfall, the model performance was encouraging but also somewhat mixed. Orographic snows, for most of our cases having moist west or northwest flow, were handled fairly well by RAMS and MM5 in terms of indicating the location of expected snowfall relative to the impinging flow. The predicted amounts under these conditions were roughly similar for each model, though there were some nonsystematic differences. When compared to actual snow that fell the results were mixed, and we hypothesize that the errors might lie in having the lateral boundary conditions supplied from a 12 h old run of the operational Eta model.

A number of the cases with northwesterly flow aloft and orographic mountain snows also had low level upslope on the plains forcing snow that increased closer to the Front Range foothills, as well as organized bands of snow well out onto the plains in association with forcing from an upper level jet streak in the presence of CSI (Convective Symmetric Instability). When the upslope was relatively shallow and the overlying northwest flow fairly strong both MM5 and RAMS underestimated the snowfall on the plains, sometimes missing the banding entirely. This may be related to excessive sinking and drying downstream of the higher terrain under such conditions with a vertical grid that is still too coarse. On most occasions though the models did retain the cold air on the plains, in contrast to the typical behavior of the Nested Grid Model (NGM). Unfortunately, we were not able to save MesoEta forecasts, but it is clearly superior to the NGM with low level cold air on the plains.

3. CASE STUDY: 20 FEBRUARY 1997

The case of 20 February 97 also involved CSI and banded distribution of snowfall, but occurred with southwesterly flow aloft. A mesoscale band of heavy snow approximately 60 km wide and 100 km long fell with amounts ranging from 5 to 10 cm on the plains close to the foothills to none farther east (2 cm fell in eastern Denver), but up to 40 cm over the higher terrain west of Denver and Boulder.

As seen in Fig. 2, the southwesterly flow at midlevels was ahead of a shortwave trough at 500 mb moving southeastward. Another trough with more extensive precipitation, all just east of Colorado, was lifting northward out of Texas. At the surface, high pressure built east across southern Wyoming, sending a surge of northeast winds past Denver at 1500 UTC. The band of snow developed before 1800 UTC from west of Denver northward past Boulder, then expanded with time (Fig. 3).

Forecasts of accumulated precipitation and near-surface winds (at a height of 150 m for RAMS and about 50 m for MM5) valid for the same time as Fig. 3 are shown for RAMS (Fig. 4) and MM5 (Fig. 5). In Fig. 6 are the surface winds, MSL pressure, and 3-h accumulated precipitation from the 1500 UTC run of the MesoEta valid at 0000 UTC 21 Feb.

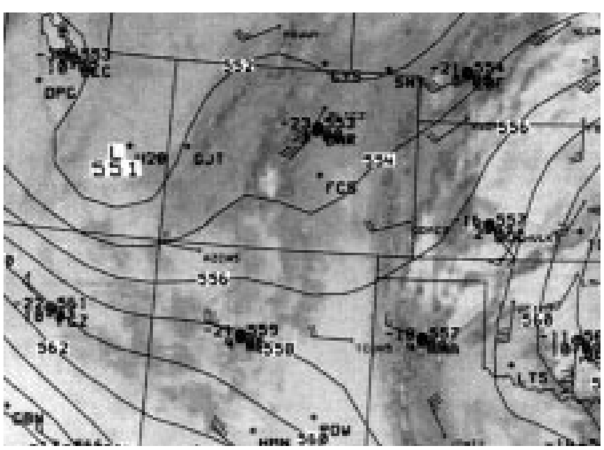

Figure 2. Eta 500 mb heights (dm) with upper air and profiler plots on IR image (white = coldest) for 2100 UTC.

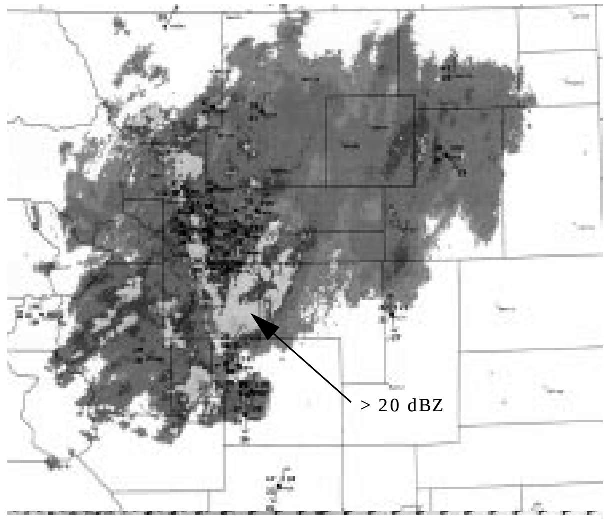

Figure 3. Radar 1 km composite reflectivity image with county map background and METAR plots for 2300 UTC 20 Feb 97.

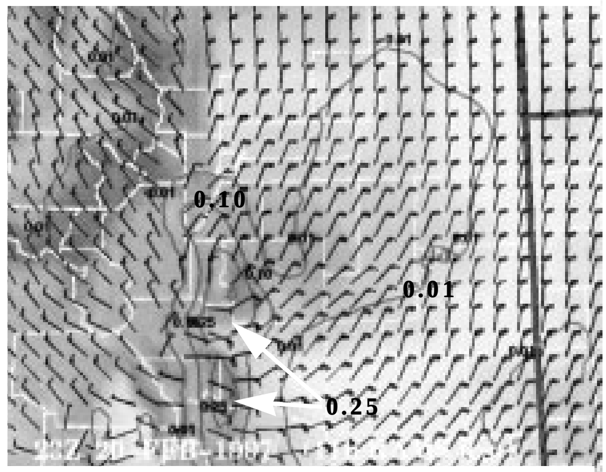

Figure 4. RAMS 11-h forecast of near surface wind and total precipitation (inches) valid for 2300 UTC 20 Feb 97.

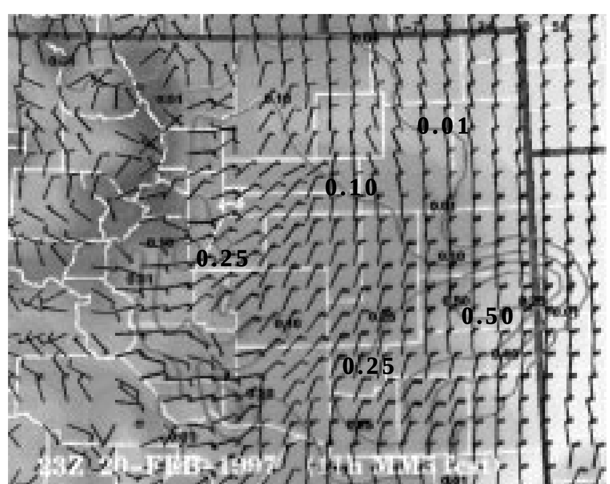

Figure 5. As in Fig. 4, for MM5 11-h forecast valid at 2300 UTC.

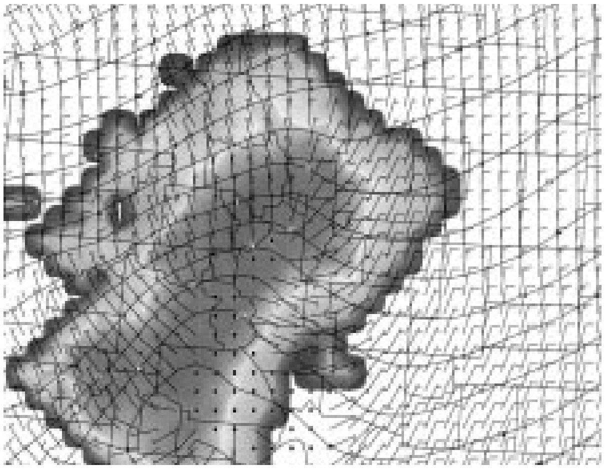

Figure 6. MesoEta 9-h forecast of surface winds MSL pressure, and 3-h precipitation (gray shading, max value ~0.10") valid 0000 UTC 21 Feb 97, on county map background.

All three models show precipitation over the foothills and nearby plains, but the MesoEta most closely captures the character of the precipitation band, with it displaced only slightly west of the actual band. RAMS shows a distinct maximum of precipitation near the Front Range, but it is displaced too far south (south of Denver in the forecast). MM5 shows precipitation farther north but weaker and not so distinct with the precipitation along the Front Range, instead indicating more light precipitation over the eastern plains. The anomalous maximum near the eastern border appears to be a band associated with the upper-level low that was over Texas (Fig. 2; this area of precipitation was in reality farther east). The turning low level wind field, somewhat of a LGM Anticyclone, is predicted best by RAMS and MM5. We suspect that better initialization for the MesoEta (1200 UTC Eta vs. 0000 UTC Eta for RAMS and MM5) may in part explain the poorer forecasts for this event. However, for another snowfall event (not shown) that was related to a somewhat smaller scale midlevel circulation moving east across Colorado, the MM5 and RAMS showed much better predictions than the MesoEta, making the above reasoning uncertain.

4. SOME OPERATIONAL ISSUES

Briefly, our experiences thus far indicate a number of issues. Though available to the WFO forecasters on the Internet, the model output was not widely used because it was not yet displayable on their WFO-Advanced workstation. Ease of output, ability to display many fields of choice and overlay actual data, etc., are important considerations when trying to bring a model to operational use. We are experimenting with three-dimensional visualization as a means of at least overviewing the immense output that is available from model grids. Thought must be given to timing of the model run (when available to the forecaster and the length of the forecast) relative to when the forecasters produce their products, while at the same time being able to initialize with the most recent larger-scale model output. Some initial tests with a version of RAMS (ExpRAMS in Table 1) run out to 26 h but only once a day, starting at 0300 UTC to utilize a more current 0000 UTC model run, and nested within a larger grid having lower resolution, have been very encouraging along these lines, as well as showing improved predictability, at least for a limited number of cases.

5. ACKNOWLEDGEMENTS

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